

Seroprevalence of *Lawsonia intracellularis* in different swine populations in 3 provinces in Canada

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Abstract — Porcine proliferative enteropathy caused by *Lawsonia intracellularis* is an important enteric disease in swine throughout the world. Information regarding the distribution of this pathogen in Canadian swine herds would be beneficial for the creation of control protocols. Pigs from Ontario, Quebec, and Alberta were tested by using an indirect immunofluorescence assay for antibodies to *L. intracellularis*. Pig seroprevalence was calculated as the proportion of pigs positive from total pigs tested in the targeted population. Seroprevalence (\pm standard error [s_x]) in market hogs in Ontario from farrow-finish (FF) farms and finishing (FIN) farms were significantly different at 77% ($s_x = 7\%$) and 29% ($s_x = 15\%$), respectively. Seroprevalence for sows and gilts in FF and farrowing and nursery (FAR + NUR) farms in Ontario were 90% ($s_x = 3\%$) and 93% ($s_x = 6\%$), respectively. Seroprevalence in breeding females in Quebec from FF and FAR farms was 82% ($s_x = 5\%$) and 87% ($s_x = 3\%$), respectively. Seroprevalence (57%, $s_x = 8\%$) in finishing pigs in Alberta from FF farms was significantly different from that of multisite (MS) farms and FIN farms, 6% ($s_x = 6\%$) and 9% ($s_x = 5\%$), respectively. *Lawsonia intracellularis* appears to be widespread in Canada and the seroprevalence on FF farms is higher than that on FIN and MS farms, possibly due to the presence of breeding females or management differences.

Résumé — Séroprévalence de *Lawsonia intracellularis* chez différentes populations porcines dans 3 provinces du Canada. L'entéropathie proliférative porcine causée par *Lawsonia intracellularis* est une maladie entérique majeure du porc à travers le monde. Une meilleure compréhension de la distribution de ce pathogène dans les troupeaux porcins du Canada serait utile pour l'établissement de protocoles de lutte contre la maladie. Dans ce but, des porcs en provenance de l'Ontario, du Québec et de l'Alberta ont été testés par détection des anticorps contre *L. intracellularis* par immunofluorescence indirecte. La séroprévalence a été définie comme étant la proportion de porcs positifs par rapport au nombre total de porcs testés dans la population cible. La séroprévalence (\pm erreur type [s_0]) chez les porcs de marché en Ontario était sensiblement différente dans les porcherie naissance-finition (NF) 77 % ($s_0 = 7\%$) comparée à celle des porcherie de finition (FIN) 29 % ($s_0 = 15\%$). La séroprévalence chez les truies et les cochettes dans les NF était de 90 % ($s_0 = 3\%$) et de 93 % ($s_0 = 6\%$) dans les maternités et les pouponnières (MAT + POU) de l'Ontario. La séroprévalence chez les truies de reproduction dans les porcherie de NF et de MAT du Québec était de 82 % ($s_0 = 5\%$) et de 87 % ($s_0 = 3\%$), respectivement. La séroprévalence (57 %, $s_0 = 8\%$) chez les porcs de finition en Alberta provenant des porcherie NF était significativement différente de celle rencontrée dans les porcherie multisites (MS) 6 % ($s_0 = 6\%$) et FIN, 9 % ($s_0 = 5\%$). *Lawsonia intracellularis* semble être largement répandue au Canada et la séroprévalence dans les porcherie NF est plus élevée que dans les porcherie FIN et MS, possiblement à cause de la présence de femelles de reproduction ou de méthodes différentes de gestion.

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Introduction

Porcine proliferative enteropathy (PPE) is an important enteric disease in swine herds throughout the world. Disease is caused by the intracellular bacterium *Lawsonia intracellularis*, which infects enterocytes mainly in the distal part of the ileum (1). Porcine proliferative enteropathy is known to occur in acute and chronic forms (1,2). The acute form is known as porcine hemorrhagic enteropathy (PHE) and usually occurs in mature (> 4 mo old) pigs. Porcine hemorrhagic enteropathy is characterized by the proliferation of the crypt cells with intestinal blood clots and fibrin casts in the ileal lumen, resulting in bloody diarrhea and acute death. The chronic form, porcine intestinal adenomatosis (PIA), is also characterized by proliferating crypt cells of the ileum and sometimes of the large intestine producing a thickening of the intestines. Porcine intestinal adenomatosis often results in diarrhea and reduced weight gains, typically in pigs 6- to 20-wk old.

Lawsonia intracellularis is spread in pigs through the fecal-oral route. Clinical signs and serum antibodies typically develop 2 to 3 wk after experimental challenge (3). Initially, the detection of *L. intracellularis* was done on postmortem samples diagnosed by gross and microscopic lesions with intracellular curved bacteria (1). Antemortem tests are now available; they include fecal PCR (4) and either an indirect fluorescent antibody test (IFAT) (3) or an immunoperoxidase monolayer assay (IPMA) (5) for serum immunoglobulin (Ig) G against *L. intracellularis*. The IFAT test is commonly used when farms are being surveyed, because it performs very well with a high diagnostic sensitivity (90%–93%) (3,6,7) and specificity (approximately 100%) (3,6).

The prevalence of *L. intracellularis* infection, as detected by fecal PCR or serum antibodies to the bacterium, has been measured in many countries, including Korea, Denmark, and the United States. In Korea, 65 different herds were tested by the IFAT; all were infected with 44% to 69% of the pigs on the farms infected (8). In Denmark, *L. intracellularis* infection was measured by fecal PCR; in 79 finishing herds tested; 94% were positive for *L. intracellularis* organisms in the feces, with 5% to 100% of the pigs on each farm infected (9). In a North American report from the Midwest United States, there was a 75% herd prevalence for growing herds and a 78% herd prevalence for breeding herds with 11%–92% and 5%–61% of the pigs, respectively, positive for antibodies to *L. intracellularis* by IPMA (10). This organism's high prevalence level in herds and pigs suggests that it likely has a significant impact on swine health in pig producing countries.

In Canada, *L. intracellularis* is believed to be a major contributor to disease in swine herds (11,12). Porcine proliferative enteropathy was the most commonly diagnosed enteric disease in grower-finishing pigs submitted to the Animal Health Laboratory at the University of Guelph in Ontario (11) and the second most common enteric diagnosis in all submissions to the provincial veterinary diagnostic laboratories in Alberta (12). However, no large-scale study of the prevalence of *L. intracellularis* infection has been performed in Canada. Information regarding the distribution of this pathogen in Canadian swine

herds would be beneficial to swine producers and veterinarians for developing appropriate control and treatment protocols to minimize the impact of this disease. The objective of this study was to determine the seroprevalence of *L. intracellularis* in targeted populations of pigs in Alberta, Ontario, and Quebec. A brief evaluation of some of the same pigs from Ontario has been reported previously, but with a different analysis and slightly different population of pigs (13). Our re-evaluation has been included because of the different statistical approach, for comparison with other provinces, and to complete the characterization of *L. intracellularis* in swine populations in Canada.

Materials and methods

Sampling protocol

Individual pig serum samples were obtained from swine serum banks in Ontario, Quebec, and Alberta. Because differing target populations were sampled from these swine serum banks for maximum information on seroprevalences and efficiency, an effort was made to maintain uniformity of the sampling protocols. Varying information (gender, age, feed, breed, medications, vaccines, etc) was available from the databases regarding the different populations of pigs.

Random sampling of farms and pigs from the existing serum banks was done by computerized random numbers. Thirty pigs/farm were selected, which allowed for the detection of at least 1 positive animal (with 95% confidence) in a herd with a minimum seroprevalence of 10% (assuming a sensitivity and specificity of 93% and 100%, respectively) (14). To allow for within strata (farm types and farm sizes) estimates of herd and pig seroprevalences and in consideration of the cost of the IFAT test, serum samples were selected from 34–36 farms from each provincial serum bank. Although the precision of the herd level prevalence within strata would be poor, the estimates should allow for the preliminary investigation of available herd and individual risk factors as they relate to serological status.

Ontario

Farms with sera stored in the Ontario swine serum bank had originally been randomly selected from all farms listed with Ontario Pork. A stratified random sample of approximately 1/3 of the farms that had sera in the Ontario serum bank were selected from each of 22 farrow-to-finish (FF) farms (all stages of pig production) of 3 different sizes (50–200 sows, 201–500 sows, and > 500 sows). In addition, 8 finishing (FIN) farms (hogs from 25 kg to market weight) and 4 farrowing and nursery (FAR + NUR) farms (farrowing sows and young pigs up to 25 kg) were selected similarly. Approximately 15 sows or gilts and 15 finishing hogs were randomly sampled from the FF farms, 30 finishing hogs were randomly sampled from the FIN farms, and 30 sows and gilts were randomly sampled from the FAR + NUR farms.

Quebec

Farms that had sera stored were originally randomly selected from all farms listed with the Quebec Pork Producers Federation, proportional to the number of farms of each farm type in Quebec. To estimate *L. intracellularis* seroprevalence in sows

Table 1. Herd and pig level seroprevalence for antibodies to *Lawsonia intracellularis* for different populations of pigs in Canada

Province	Population		Herd seroprevalence (s_x)	Pig seroprevalence (s_x)	Range of seroprevalence in farms
Ontario	8 FIN farms	(237 finishing pigs)	87.5% (11.7%)	29.1% ^a (14.7%)	0–1
	22 FF farms	(328 finishing pigs)	95.5% (4.4%)	77.1% ^b (6.6%)	0–1
		(326 sows/gilts)	100% (0%)	89.9% (2.9%)	0.50–1
	4 FAR + NUR farms	(118 sows/gilts)	100% (0%)	93.2% (5.7%)	0.77–1
Quebec	18 FF farms	(538 sows/gilts)	100% (0%)	82.2% (5.1%)	0.17–1
	18 FAR +/- NUR farms	(535 sows/gilts)	100% (0%)	87.1% (2.6%)	0.55–1
Alberta	24 FF farms	(691 finishing pigs)	91.7% ^c (5.6%)	56.7% ^c (7.6%)	0–1
	6 FIN farms	(177 finishing pigs)	50.0% (20.4%)	8.5% ^d (4.5%)	0–0.24
	6 MS farms	(173 finishing pigs)	16.7% ^d (15.2%)	5.8% ^d (5.7%)	0–0.33

FF — farrow-to-finish farms, FIN — finishing farms, FAR — farrowing farms, NUR — Nursery, MS — Multisite farms; ^bsignificantly higher than^a, ^csignificantly higher than^d with $P < 0.05$

and gilts in Quebec, a stratified random sample of 36 farms from the farms that had sera stored at the Quebec serum bank were selected. Farm type stratum included 18 FF and 18 FAR +/- NUR farms and farm size stratum included farms with 50–100 sows, 101–200 sows, and > 200 sows. Serum samples from approximately 30 sows and gilts were randomly selected from each farm for testing for antibodies to *L. intracellularis*. Because the farms in the serum bank had been selected proportionally to the number of farm types in Quebec, a weighted survey analysis was used to estimate an overall province seroprevalence in sows and gilts.

Alberta

Swine farms in Alberta were chosen by 10 swine veterinarians, based on an annual farm production of 2000 or more market pigs and the willingness of producers to donate sera to the serum bank in Alberta. These farms included FF, multisite (MS) farms (in which individual stages of pig production are housed at different locations), and FIN farms.

To estimate *L. intracellularis* seroprevalence in finishing pigs in Alberta, 36 farms were selected by stratified random sampling. Farm type stratum included 24 FF, 6 FIN, and 6 MS farms, and farm size stratum for the FF included farms with < 200 sows, 200–499 sows, and > 499 sows. Sera from 30 hogs that were within 45–60 d of shipment were submitted for antibody testing.

Antibody testing

All serum samples were tested in September through October 2002 by using a glass slide indirect immunofluorescence antibody test (IFAT) for IgG antibodies to *L. intracellularis* tested at the Groupe de recherche sur les maladies infectieuses du porc (GREMIP) laboratory in St-Hyacinthe, Quebec. This test is based on the IFAT reported by Guedes et al (7), with some modifications. Briefly, plates consisted of glass slides (15-well multitest slide; ICN, Aurora, Ohio, USA) coated with killed bacterial antigen, provided by Dr. S. McOrist (QAF Industries; Corowa, New South Wales, Australia). The antigen consisted of cultured *L. intracellularis* that had been killed in 10% formalin and then attached to the plates by double cold

fixation in 100% acetone. Sera were tested at a dilution of 1:30. After being washed, the wells were incubated with antibodies to swine IgG conjugated with fluorescein isothiocyanate (Jackson ImmunoResearch Laboratories, West Grove, Pennsylvania, USA) and the wells were observed with a fluorescence microscope. All slides were read by the same technician.

Statistical analysis

Herd seroprevalences for the different populations were calculated as the proportion of farms that had at least 1 pig that tested positive for antibody to *L. intracellularis*. Significant differences between herd level seroprevalences within provinces were evaluated by a Fisher's exact test. Pig level seroprevalences (proportion of positive pigs) and standard errors of antibodies to *L. intracellularis* in the different pig groups were calculated by using survey data analysis techniques that incorporate linearization variance estimators for the standard error estimates to account for the clustering of pigs within a farm (15). Strata were based on both the different farm sizes and types. Because pigs that were sampled from within 1 herd were not independent from one another (the pigs were clustered within a herd), the specified primary sampling unit was the herd. It was possible to assign sampling weights for the Quebec herds, which were calculated as the inverse of the probability that the herd would be selected from a particular farm size in the province (16). Significant differences between the seroprevalences of the different farm types and sizes, as well as between other groups based on age and sex, were assessed by using similar linearization variance estimators with $P < 0.05$ as being significantly different. When more than one comparison of seroprevalences was made, the Bonferroni adjusted level of significance was used. All analyses were performed by using statistical software (Stata, ver. 7, Statacorp, College Station, Texas, USA).

Results

The number of farms and pigs of each type for each province are presented in Table 1. Not every farm had 30 available serum samples; thus, between 26 and 30 pigs were sampled at each farm. Also presented in Table 1 are herd level seroprevalences and pig level seroprevalences by farm type for each province.

Table 2. Pig level seroprevalence for antibodies to *Lawsonia intracellularis* for hogs and sows/gilts for different size farrow to finish farms in Ontario and Alberta, and on farrow to finish farms and farrowing farms with and without a nursery in Quebec

Province	Pig type	Pig level seroprevalence (s_x) for different farm sizes and number of farms					
		< 200 sows		200–499 sows		≥ 500 sows	
Ontario	Finishing pigs	77.0% (11.1%)	$n = 10$	88.3% (4.3%)	$n = 8$	55.0% (21.8%)	$n = 4$
	Sows/gilts	86.5% (5.6%)	$n = 10$	94.1% (2.7%)	$n = 8$	90.0% (5.8%)	$n = 4$
Alberta	Finishing pigs	63.3% (13.3%)	$n = 8$	39.5% (15.5%)	$n = 9$	67.1% (10.4%)	$n = 13$
		50–100 sows		101–200 sows		> 200 sows	
Quebec	Sows/gilts	92.2% (3.1%)	$n = 9$	82.1% (6.4%)	$n = 11$	79.6% (4.9%)	$n = 16$

Table 3. Overall pig level seroprevalence to antibodies to *Lawsonia intracellularis* for hogs and sows/gilts for farms in Ontario, Alberta, and Quebec

Province	Pig type	Pig level seroprevalence (s_x)
Ontario ^a	Finishing pigs	57.0% (7.2%) ^c
	Sows/gilts	90.8% (2.6%) ^d
Quebec ^b	Sows/gilts	84.4% (3.1%)
Alberta ^a	Finishing pigs	40.1% (5.2%)

^a Farms were not selected proportionally and total number of farms of each type was not available, therefore seroprevalence represents only the average of pigs in the farms that were sampled. ^b Farms from Quebec were sampled proportionally to the types of farms in Quebec and therefore the seroprevalence represents an overall average in all sows and gilts in Quebec. ^c significantly higher than ^d with $P < 0.001$

Ontario

There were no significant differences between the different farm types for herd level prevalence (Table 1). For finishing pigs, the mean pig level seroprevalence in the FF type was significantly higher than that for pigs in the FIN type ($P = 0.006$) (Table 1). For all sows and gilts, pig level seroprevalences of *L. intracellularis* for the FF type and for the FAR + NUR type were not significantly different from one another (Table 1). The different size farrow-finish farms based on the number of sows on the farm were not significantly different from each other (Table 2). In all farms in Ontario, the sows and gilts had a significantly higher seroprevalence ($P < 0.001$) than the finishing pigs (Table 3). The seroprevalences for gilts were not significantly different from those of the sows in the FF and FAR + NUR types (Table 4).

Quebec

All 36 farms that participated in this study had at least 1 sow or gilt positive for antibodies to *L. intracellularis*. The overall pig level seroprevalence for all female breeding animals for all herds in Quebec was 84.4% ($s_x = 3.1\%$) (Table 3).

Pig level seroprevalences in sows or gilts by farm type were not significantly different from one another (Table 1). Seroprevalences by farm size were not significantly different from one another (Table 2). The seroprevalence of all sows was significantly higher than in gilts ($P = 0.009$) (Table 4).

Alberta

The proportion of farms in Alberta that had at least 1 finishing pig positive for antibodies to *L. intracellularis* was significantly

Table 4. Pig level seroprevalence antibodies to *Lawsonia intracellularis* and the P -value for the test of their difference for sows and gilts for farms in Ontario and Quebec

Province	Farm type	Sow level seroprevalence (s_x)	Gilt level seroprevalence (s_x)	P -value
Ontario	FF and FAR + NUR	91.1% (3.3%)	91.8% (5.4%)	0.91
Quebec	FF and FAR +/- NUR	86.9% (2.4%)	64.1% (9.4%)	0.009

FF — farrow-to-finish farms, FIN — finishing farms, FAR — farrowing farms, NUR — Nursery

higher for the FF type compared with the MS type ($P = 0.0001$) (Table 1). The significant difference for herd seroprevalences was marginal ($P = 0.06$) between the FF and the FIN types, but not significantly different between the FIN and MS types.

The pig level seroprevalence for the FF type was significantly higher than the seroprevalences of the FIN type ($P < 0.001$) and the MS type ($P < 0.001$) (Table 1). Seroprevalences by farm size of the FF type were not significantly different from each other (Table 2).

Discussion

Herd level seroprevalences were very high for all 3 provinces, except for the MS and FIN herds in Alberta, indicating that the organism has a significant presence in all 3 provinces. Likewise, pig level seroprevalences were very high in all farms in the 3 provinces, except for the FIN and MS farms that were tested. Interestingly, these 2 types of farms (FIN and MS), which have a lower seroprevalence, do not house breeding sows and gilts with finishing pigs in the same facility, or even on the same farm. This separation of breeding animals from finishing animals and the lack of exposure of the breeding animals to the finishing animals may be 1 reason for the lower *L. intracellularis* seroprevalence. Another possibility for these appearing to be lower exposure of *L. intracellularis* in the FIN and MS farms is the management of the pigs. The FIN and MS farms in Alberta were less likely to use a continuous flow of pigs through the facilities and more likely to practice the all-in, all-out type of management (unpublished observations). Complete destocking of facilities has been shown to reduce the risk of disease by at least half (2,9,17), potentially because of improved removal of

Table 5. Summary of the effect on herd prevalence caused by moving the cut-off for a positive farm from 1 positive pig up to 3 positive pigs

Province	Pig type	Proportion of positive farms based on different number of positive pigs as a cut-off for being a positive farm		
		1 positive pig	2 positive pigs	3 positive pigs
Ontario	FF	95.5%	90.9%	90.9%
	FIN	87.5%	75.0%	62.5%
Alberta	FF	91.7%	83.3%	79.1%
	FIN	50.0%	50.0%	33.3%

FF — farrow-to-finish farms, FIN — finishing farms

feces and disinfection. Given that known risk factors for PPE in pig herds are having a *L. intracellularis* seropositive breeding animal on the farm and having a continuous flow management, absence of these risk factors may have resulted in the lower seroprevalence seen in the FIN and MS farms.

In this study, the size of the farm according to the number of sows on the farm did not seem to be an important factor in determining high seroprevalence herds. This is unlike a previous report in which it was suggested that, on British swine farms the size of the farm was an important risk factor for PPE (2). In the British risk factor study, farms that had > 500 sows had double the risk of having PPE in the herd. Possible reasons for this increase in risk were the increased contact of pigs in larger farms or increased observation of pigs on smaller farms. For all 3 provinces that we investigated, there was no association with the number of sows on a farm and the risk of PPE, however, this should be interpreted cautiously, due to the relatively low number of farms in each size category.

The IFAT test was used in this study because it has been shown to perform very well for the detection of specific antibodies against *L. intracellularis* (3,6,7). The ability of the test to identify nonexposed pigs (the test's diagnostic specificity) has been shown to be extremely high, near or at 100%. Because the test's specificity is so high, we chose the cut-off of 1 positive pig from a farm to indicate that the farm was positive. Since the small chance of having a false positive test result is small, we could have made the cut-off 2 or even 3 positive pigs for the farm to be considered positive and thereby improved the herd specificity (ability of the test to identify a truly negative herd) of the test (14). By moving the cut-off to 2 positive pigs, the status of 2 of the 34 farms with finishing pigs in Ontario would change — adjusting the herd prevalence to 75.0% for the FIN and 90.9% for the FF farms; the status of 2 of the 36 Alberta farms would change — adjusting the herd prevalence to 83.3% for the FF farms. Moving the cut-off to 3 positive pigs would change the herd prevalence of the FIN Ontario farms to 62.5% and the FF and FIN Alberta farms to 79.1% and 33.3%, respectively. Changing the cut-off would not have altered the herd prevalence for farms in Quebec. Moving the cut-off up to 2 or 3 positive pigs increases the herd specificity of the test and results in a reduction of the estimated herd prevalence in some of the farm types, but at the same time, it weakens the herd sensitivity of test (test's ability to identify a positive herd), especially on

farms with a low prevalence of antibodies to *L. intracellularis*. A summary of the changes in herd level prevalence according to the number of positive pigs used to define a positive herd is presented in Table 5.

The IFAT test identifies previous exposure to *L. intracellularis*, not current infection (3). With the use of the IFAT, it has been reported that IgG antibodies specific for *L. intracellularis* are detected 3 wk after infection (3); they can be short lived, up to 3 wk in growing pigs and replacement gilts (10), or last up to 3 mo in gilts after a PHE outbreak (18). Because the antibodies take time to develop and will eventually wane, there is a short window of time in which tested pigs will be positive for antibodies. Therefore, the seroprevalence of the populations tested may actually be lower than the true infection rate.

Because the farms from each province were not originally sampled identically for sera in the serum bank, it would be inappropriate to compare the seroprevalences between the different provinces. We also were not provided with the probability of each pig being selected from all pigs in the province, which would have allowed for the estimation of the overall seroprevalences for the pigs in each province (15). However, we were able to calculate an approximate province-wide sow and gilt seroprevalence for Quebec, because we were provided with the probability of sampling a farm from FF and FAR +/- NUR farms in the province. This seroprevalence was very high at 84.4% ($s_x = 3.1\%$), reiterating the fact that housing breeding animals with finishing animals may result in an increase of *L. intracellularis* infection in the finishing pigs.

Although the use of a serum bank was an extremely efficient method of testing the pigs, it did present one limitation. We did not have access to specific information regarding the swine herds. In particular, information regarding antibiotic usage, vaccines, and management practices potentially would have allowed more conclusions regarding the differences in seroprevalences among the different groups.

The high seroprevalences in the targeted populations that we tested indicate that *L. intracellularis* infection is pervasive in Canada, as it is throughout the world. Because *L. intracellularis* can create a variety of different enteric diseases in pigs, the economic impact that this organism has on the Canadian swine industry must be great. Options to reduce disease include both limiting risk factors, such as having seropositive breeding pigs with finishing pigs, and using a continuous flow system, and having well-timed medication schemes for prevention and treatment of PPE.

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Book Review

Compte rendu de livre

Veterinary Endoscopy for the Small Animal Practitioner

McCarthy TC. Elsevier Saunders, St. Louis, Missouri, USA, 2005, 600 pp. ISBN 0-7216-3653-5.

This book is an excellent text for anyone interested in small animal endoscopy. It is an ideal complement to “Tod Tam’s Small Animal Endoscopy”. The approach in McCarthy’s book contrasts to Tam’s in that McCarthy is a surgeon, not an internist. As a result, McCarthy’s book gives considerably more information on rigid endoscopy including some surgical procedures. The sections on thoracoscopy, laparoscopy, otoscopy, and arthroscopy are especially valuable and detailed.

The book contains hundreds of high-quality illustrations. A very handy feature is the combination of an endoscopic image together with a line drawing that explains the pertinent anatomic findings. This makes understanding the image considerably easier, even if you have no prior experience in this area. All areas of endoscopy are covered in detail including bronchoscopy, rhinoscopy, cystoscopy, thoracoscopy, upper and lower GI endoscopy, laparoscopy, otoscopy, vaginoscopy, arthroscopy as well as “otheroscopies”. Each chapter details indications for the procedure, equipment needed, patient preparation, how to carry out the technique and potential complications. When

appropriate, the text will detail normal and abnormal findings, though in most instances this is mainly accomplished with images. The equipment section is often very detailed covering all instrumentation options and requirements. When indicated, both rigid and flexible endoscopy techniques are detailed. In some cases the information on flexible endoscopy is limited such as with cystoscopy or rhinoscopy, though this does not detract from the value of this book.

The initial 3 chapters of this book that deal with an introduction to endoscopy equipment, anesthesia and endoscopic biopsy handling and histopathology are clinically useful as well. Anesthesia is generally needed for these procedures and endoscopy can present significant anesthetic challenges. In some instances the chapters also contain information on anesthesia for a particular procedure.

Timothy McCarthy’s *Veterinary Endoscopy for the Small Animal Practitioner* is a well-written and very richly illustrated book. For veterinarians that perform endoscopy as well as for those considering getting into the field this is truly an indispensable book.

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